DAMES & MOORE

GROVE PARK PLACE, 1750 FRONT STREET, SUITE 100, BOISE, IDAHO 83702
(208) 344-6140 FAX: (208) 338-9063

TRANSMITTAL

TO: Kennecott PDEIS (Jan. 27, 1995) Reviewers

U.S. Army Corps of Engineers
Art Champ
Larry Vinzant
Mike Schwinn
Brooks Carter

Department of Environmental Quality
John Whitehead
Randy Taylor

Kennecott Utah Copper Corporation
Bob Dunne
Paula Doughty
Ric Jones

Dept. of Lands, Div. of Oil, Gas, Mining
Wayne Hedberg

FROM: Dames & Moore

DATE: February 6, 1995

RE: **Replacement of the Ground Water Supply Section**

The following subsection should replace *Section 3.3.3 Ground Water Supply* (pp. 3-60 to 3-66) in your January 27, 1995 Kennecott Tailings Modernization Project Preliminary Draft Environmental Impact Statement.

We appreciate your reviewing the document and ask that you send your comments to Mike Schwinn by February 17, 1995.

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To Wayne Hedberg	From Nancy Olmsted
Co./Dept. DOGM	Co.
Phone #	Phone # (208)344-6140
Fax # 801-359-3940	Fax # (208)338-9063

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and some of the ground water provides recharge to the Shallow and Principal aquifers. Most springs which discharge from the Bedrock Aquifer are located along the contact between the less permeable lacustrine sediments and alluvial/colluvial sediments that occurs at approximately along the 4235-foot topographic elevation contour. Some historic springs located along this elevation contour have been covered by the existing tailings impoundment. Hydraulic conductivities in the Bedrock Aquifer are estimated from slug and short-term pumping tests to range from $1x10^{-4}$ up to $1x10^{-1}$ centimeters per second (cm/s).

The Bedrock Aquifer is overlain by more than 1,200 feet of sediment in the area north of the existing tailings impoundment. Based on stratigraphy and differences in water quality and hydraulic head, this sedimentary sequence has been divided into the Principal Aquifer and overlying Shallow Aquifer.

Principal Aquifer

The Principal Aquifer is confined and consists of clay, silt, sand, and gravel deposits with individual beds raging in thickness from less than one to several tens of feet. Sediments located below the Shallow Aquifer and above the underlying semiconsolidated sediments and bedrock are included in the Principal Aquifer. These sediments include a confining zone that separates the unconfined shallow aquifer from the confined Principal Aquifer. Ground water flow in the Principal Aquifer is toward the north-northwest.

The Principal Aquifer in the Great Salt Lake area is subdivided into a lacustrine zone and a gravel zone. The lacustrine zone consists primarily of clays and interbedded fine-grained sands. The gravel zone consists of coarse-grained sediments transported from the mountains during an extended period of low Great Salt Lake elevations. Large capacity wells located near the Oquirrh Mountains are completed in the gravel zone of the Principal Aquifer. Slug tests and short-term pumping tests of the upper part of the Principal Aquifer indicate average hydraulic conductivities of 3x10-5 cm/s for lacustrine to $4x10^{-4}$ cm/s for gravel zone wells. Horizontal hydraulic conductivities within the Principal Aquifer are estimated to be $2x10^{-3}$ cm/s versus vertical hydraulic conductivities of $3x10^{-5}$ to $4x10^{-4}$ cm/s.

Shallow Aquifer

The unconfined Shallow Aquifer consists of the lacustrine Bonneville Clay and interbedded clays and fine sands of the underlying Cutler Dam Series. These sediments directly overlie the Bedrock Aquifer in some areas, but in most cases, the Shallow Aquifer overlies a 50-foot thick bed of reduced permeability material that confines ground water in the underlying Principal Aquifer.

Water level elevations measured in the Shallow Aquifer generally follow ground surface elevations. Upward vertical hydraulic gradients result in the discharge of ground water to the surface via springs and seeps which in some cases feed surface water bodies such as lakes, streams and canals and in other cases feed mudflats. Where ground water is discharged to lakes, streams, and canals

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3.3.2 Ground Water Supply

3.3.2.1 Overview

The focus of this section is potential impacts to ground water supply. Potential impacts to ground water quality are discussed in Chapter 3, Ground Water Quality Section 3.3.3 and hazardous waste/materials issues associated with ground water are discussed in Chapter 3, Hazardous Waste/Materials Section 3.8

Methods

An understanding of ground water flow in the vicinity of the Tailings Impoundment and potential impacts of proposed alternatives was developed from a review of documents listed in Chapter 6, References, Section 3.3.

3.3.2.2 Issues

Issues associated with the ground water include potential changes to the:

- local vertical and horizontal hydraulic gradients and flow directions,
- quantity of ground water discharged to toe drain collection ditch,
- quantity of ground water discharge to springs and seeps that feed nearby wetland areas, and
- water levels in and capacities of nearby ground water production wells.

3.3.2.3 Affected Environment

Water quality and water level elevation data for wells and springs in the area have been used in various reports to characterize the occurence and movement of ground water in the area of the Tailings Impoundment and North Expansion. The three main aquifers identified in the Great Salt Lake area are the Bedrock Aquifer, the confined Principal Aquifer, and the unconfined Shallow Aquifer. A conceptual cross-section is provided on Figure 3-2.

Bedrock Aquifer

Ground water flow within Paleozoic bedrock in the northern Oquirrh Mountains is anticipated to occur along fractures. Where these fractures are connected and saturated they form the Bedrock Aquifer. Recharge to the Bedrock Aquifer is from precipitation in the Oquirrh Mountains. No perched zones have been reported for the north end of the Oquirrh Mountains which indicates that fracturing is extensive and well connected.

Ground water within the Bedrock Aquifer in the northern Oquirrh Mountains moves in a northerly direction. Some of the ground water in the Bedrock Aquifer is discharged from wells and springs, in this area, the locations of these features are reflected in the contours of the potentiometric surface. Horizontal ground water flow is to the north-northwest. Some ground water is discharged to Great Salt Lake.

Slug tests and short-term pumping tests indicate that horizontal hydraulic conductivities range from $5x10^{-5}$ to $4x10^{-3}$ cm/s. Laboratory tests of samples of the Shallow Aquifer indicate that vertical permeabilities range from $2x10^{-8}$ to $4x10^{-7}$ cm/s. Permeabilities for triaxial tests performed on the Bonneville Clay ranged from $4x10^{-7}$ cm/s at low confining stresses to $6x10^{-9}$ cm/s for high confining stresses. These data indicate that:

- horizontal hydraulic conductivities are at least two to three orders of magnitude (100 to 1000 times) greater than vertical permeabilities, and

- the vertical permeability of the clays has been reduced by up to two orders of magnitude (100 times) by the weight of the existing tailings impoundment.

Hydraulic Gradients

At most locations in the area of the existing tailings impoundment, hydraulic heads are higher in the bedrock aquifer than in the overlying Principal Aquifer and higher in the Principal Aquifer than in the overlying Shallow Aquifer. These head differences result in upward vertical hydraulic gradients from the Bedrock Aquifer to the Principal Aquifer, from the Principal Aquifer to the Shallow Aquifer, and from the Shallow Aquifer to the ground surface. This upward vertical gradient is reversed and vertical ground water flow is changed from upward to downward under the existing tailings impoundment. Horizontal hydraulic gradients result in overall horizontal ground water flow that is in a northwest direction across the study area, toward Great Salt Lake.

Horizontal hydraulic gradients flatten toward the north from 0.002 near the Bedrock Aquifer to 0.0005 near Great Salt Lake. Vertical hydraulic gradients between the Principal Aquifer and Shallow Aquifer range from 0.05 to -0.3, and average -0.1 with the negative value indicating an upward gradient. The ratio of horizontal to vertical hydraulic gradients (1:100) when compared to the ratio of horizontal to vertical hydraulic conductivity of the aquifer materials (1000:1) indicates that ground water will be discharged from the Principal Aquifer to the Shallow aquifer within a distance of about ten times the aquifer thickness. These numbers indicate that the length of the ground water flow paths within the Principal Aquifer are relatively short and that transport of water over great distances through the Shallow Aquifer is generally not possible.

Downward vertical gradients beneath the existing tailings impoundment indicate the potential for discharge of tailings water into the underlying Shallow Aquifer. Although the potential exists, the actual quantity of flow discharged is very small due to the very small vertical and relatively larger horizontal conductivities of this aquifer at this location. The existing tailings impoundment overlies part of the Bedrock Aquifer. In these areas, the recharge of the Bedrock Aquifer by overlying existing tailings impoundment water is not prevented by the presence of the Bonneville

Clay. However, recharge from the existing tailings impoundment into the Bedrock Aquifer has been limited by the small vertical hydraulic conductivity (generally less than 10-6 cm/s) of the overlying tailings.

Ground Water Use

Ground water is used in the Great Salt Lake area for industrial, municipal, and residential purposes; however, the nearest municipal wells are at least 2 miles upgradient (south) of the existing tailings impoundment. This water is generally obtained from the gravel zone of the Principal Aquifer and spring discharges from the Bedrock Aquifer. Utilization of the Shallow Aquifer is greatly limited due to its very low well yield potential and general poor quality of water.

Most water supply wells in the area are completed in the gravel zone of the Principal Aquifer. Capacities of water supply wells completed in the Principal Aquifer range from 15 to 10,000 gallons per minute (gpm) according to permitted water rights. Springs are located along the contact between the Bedrock Aquifer and unconfined Shallow Aquifer. Adamson Spring discharges approximately 6000 gpm and is used by Kennecott as process water.

3.3.2.4 Environmental Consequences

Impact Types

Impact types include potential changes to:

- local vertical and horizontal hydraulic gradients,
- local vertical and horizontal ground water flow directions and rates,
- rate of discharge from springs and seeps which feed wetland areas to north of proposed alternatives, and
- water levels and capacities of nearby ground water production wells.

Impacts to ground water quality are addressed in Chapter 3, Ground Water Quality Section 3.3.3.

Impact Locations

Impact locations include:

- footprints of the existing and the proposed tailings impoundment,
- toe drain collection ditch,
- nearby springs and seeps, and
- nearby ground water production wells.

3.3.2.5 Comparison of Alternatives

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Individual alternatives are described as follows:

No Federal Action

With No Federal Action, tailings would continue to be discharged to and raise the elevation of the existing tailings impoundment. Change in the existing impacts would be limited to increased downward pressure and steepening of local downward hydraulic gradients. As indicated, downward flow of water from the existing tailings impoundment into Shallow Aquifer is very limited.

North Expansion West

With the North Expansion West, tailings would continue to be discharged to the existing Tailings Impoundment until a maximum height of 250 feet is reached. A new 3294-acre impoundment immediately adjacent and to the north of the existing tailings impoundment would be constructed. This area is underlain by a continuous 9-foot thick layer of the Bonneville Clay. The new tailings impoundment would be 250 feet high.

Impact intensity and duration are summarized in the following paragraphs.

Changes to Hydraulic Gradients - Hydraulic gradients are expected to be reversed from upward to downward under the footprint of the North Expansion West. Although hydraulic gradients are expected to remain downward under the existing tailings impoundment; the magnitude of the downward hydraulic gradient is expected to decrease with time after the existing tailings impoundment is closed and pore pressures in the Bonneville Clay decrease.

Changes to Ground Water Flow Directions and Rates - Due to the small vertical permeabilities and relatively larger horizontal permeabilities of the of the Bonneville Clay and of the tailings themselves, horizontal flow is expected to dominate. Upward ground water flow in the upper part of the Shallow Aquifer is expected to be changed to horizontal flow resulting in radial flow out to the drainage blanket.

Rate of Discharge from Springs and Seeps - Ground water currently discharged to the ground surface from the Shallow Aquifer in the proposed footprint will be directed radially out from the new tailings impoundment and be captured by the drainage blanket. The rate of discharge from springs and seeps is not expected to be greatly affected.

Water Levels and Capacities of Wells - Water level elevations and capacities of ground water production wells are not expected to be impacted because ground water will not be extracted and because impacts to hydraulic gradients and flow directions are expected to be small limited to the footprint of the alternative.

4.3.2.6 Proposed Mitigation

Impacts to ground water will be mitigated using the following methods of discharge control:

- Naturally deposited layers (Bonneville Clay) below the impoundment will effectively act as liners and provide the needed restriction to limit discharge of tailings water.
- Drainage ditches constructed along the edges of the impoundment, as well as natural springs occurring along the southern edge of the impoundment, will act as a radial discharge capture zone for tailings water that may be discharged to ground water.